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PATENT SPECIFICATION

NO DRAWINGS

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COMPLETE SPECIFICATION

Improvements in or relating to Security Documents and Monetary Tokens

We, THOMAS DE LA RUE AND COMPANY LIMITED, a British Company of 110 Bunhill Row, London, E.C.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —

THIS INVENTION relates to security documents and monetary tokens which can readily be distinguished from counterfeits, and to the production of such items.

Vending machines are commonly operated by the insertion therein of coins, the weight, shape and size of which are adapted, in any given instance, to cause the delivery mechanism to operate in accordance therewith. With the development and increasing acceptance of vending machines, there is a need for tokens or other mechanism-actuating devices which represent greater monetary values than those of the largest value coins now in use. Unmodified blanks of suitable weight, shape and size would not be suitable for this purpose because they could be virtually valueless *per se* and could easily be produced and used fraudulently to cause machines to operate. Suitable tokens or other devices would necessarily have to include and to operate the delivery mechanism partly at least in accordance with a constant characteristic thereof, other than weight, shape or size, which has been specially imparted thereto and which cannot readily be created or reproduced by unauthorised persons.

Further, there is a demand, which has not so far been met, for security documents such, for example, as bank notes whose genuineness can be easily and instantaneously tested in the presence and without the knowledge of a person presenting them, and without damage or any alteration to the documents themselves. It is also desirable, though by no means necessary, that the said means of authentication could be provided in the course of the printing of the documents, and so should be independent of the paper used.

The present invention provides such documents and tokens and also a method of producing them and compositions to be used in this method.

According to the invention there is provided security documents and monetary tokens, which comprise one or more radioactive marks formed from a radioactive material of atomic number less than 15 and wherein the radiation emitted is *beta* radiation energy of less than 0.5 MeV. Such security documents may have the radioactive material applied to or incorporated in the paper of the document. The radioactive material emits all or substantially all of its radiation as radiation of low penetrating power and it may be preferably less than 0.2 MeV. The material should also have a fairly long half-life, dependent on the intended life of the document. For most purposes the carbon isotope C^{14}, which emits *beta* radiation with an energy of 0.15—0.16 MeV and has a half-life of

[*Price*

about 5500 years, is satisfactory, but other radioactive isotopes can be used, e.g. tritium (H^3). The various isotopes can, of course, be used in appropriate compound, especially in salts of low or negligible solubility; for example C^{14} is usefully employed as an alkaline earth metal carbonate, especially barium carbonate, Sr^{90} can be used as the carbonate or as some other substantially insoluble strontium salt. Tritium can be present in an organic compound of a printing ink or a coating, as described more fully below. Any radioactive element may, and usually will, be present in admixture with the normal non-radioactive form of the same element.

It is an important preferred feature of the invention that the radiation emitted should be weak and incapable of penetrating paper to any considerable depth, partly for reasons of safety and partly also because this makes it possible to increase the difficulty of imitating the documents, as more fully described below. Not only the energy but also the amount of radiation may be quite low, being limited only by the sensitivity of available detecting devices, and this also makes for safety in the use of the invention.

It is quite possible to incorporate the radioactive material in the paper from which the document is made. For example, it may be distributed throughout the pulp from which the paper is made so that it is uniformly distributed through the thickness and over the area of the paper, or it may be present locally, as for instance in a security thread or individual fibres which may be concentrated in a given area, e.g. as a continuous band or as a design of some kind. Alternatively, the radioactive material may be present in a coating applied to the paper; for example C^{14} or tritium may be present in an organic component of a resinous coating; in such cases it is preferred to include the radioactive material in a coating on one side only of the paper, or that it should be present as different designs on the two sides of the paper.

Generally speaking, however, it is preferred that the radioactive material should be included in ink used to print either the whole document or selected parts thereof. Advantageously it is included in the ink used to print part or the whole of one side only of the document, the printing on the other side being non-radioactive. Ink containing barium carbonate in which part or all of the carbon is in the form of the isotope C^{14} is particularly suitable, as well as inks containing other suitable radioactive materials of comparable activity, and preferably also comparable insolubility in water. The printing of the documents with such inks is also included within the scope of the invention.

The ink, paper and method of printing are preferably selected so that substantially all of the ink remains on or close to the surface to which it is affixed, with little or no penetration of the opposite side of the paper.

The invention also provides a method of making a security document wherein a radioactive material having an emission of low penetration energy is incorporated in the paper pulp from which the document is manufactured. Alternatively, the radioactive material may be applied to the surface of the document.

A token according to the invention may comprise a radioactive material which emits a radiation of a predetermined penetration range and intensity range. Such a token may be used to actuate the delivery mechanism of an automatic vending machine by the radiation emitted by the token, the mechanism being actuated only by radiation of a given penetration range and intensity range.

Any convenient substance may be used as the base material for the token or other object, but preferably it includes one or more synthetic resins in moulded, reinforced or laminated form. A preferred method of adding the radioactivity is by using a radioactively labelled compound which reacts with the resin during the production of the token.

The radioactive isotope or element may be present in, on or beneath one or both faces of the token, and may be mixed with the synthetic resin, contained in a reinforcing or carrier material for the resin, or present in the form of ink or other marking or colouring ingredient applied externally or internally to the token. Additionally, the characteristics of the tokens may be modified by including in the tokens a barrier material resistant to radiation and so capable of reducing the energy of the radiation actually emitted on either or both sides.

A suitable delivery mechanism actuable by the tokens of the present invention is actuated by an electric circuit which includes an electronic component adapted to be influenced by a mechanism, for example one or more geiger-counter type devices, capable of being activated by the radiation emitted by the token.

Sensing mechanism systems involving differential activation of a pair of suitably interconnected geiger-muller tubes are particularly advantageous. For example, when isotopes having low penetration energy of radiation are used, one geiger-muller tube may be adapted to be activated by radiation of low penetration energy and the other only by radiation of high penetration energy; the sensitivity of the latter tube may conveniently be restricted by providing its window with

a shield, e.g. of thin aluminium. In such an instance the electric circuit controlling the delivery mechanism is preferably arranged in such a way that delivery occurs only when the geiger-muller tube accepting low penetration energy radiation is activated, but the geiger-muller tube accepting only high penetration energy radiation is receiving only the degree of activity normally associated with a background radiation from cosmic and other extraneous sources. A token containing an isotope or element which emits particles with a high penetration energy would cause both geiger-muller tubes to be activated and delivery would not be effected.

In a two geiger-muller tube system the tubes may be placed to observe a single active face or, alternatively, they may be placed one on each side of the token. If the token has radioactive material on both surfaces a shield must be used to restrict the sensitivity of one of the geiger-muller tubes so that it will receive only high penetration energy radiation, but if a token having radioactive isotope on one side only is used the token itself can be used as a shield; the token can then be observed by two identical tubes, one on either side, since by correct choice of the materials used for the token it can be arranged that the tube remote from the radioactive side of the token is activated only if the isotope is of high penetration energy.

Alternatively, the electric circuit may be so arranged that the delivery mechanism is activated by tokens containing isotopes of only high penetration energy. In any arrangement it is preferable that the electric circuits in the vending machine are so arranged that the delivery mechanism is activated only when the energy or number of particles emitted by the radioactive isotopes lies between defined limits.

The following methods for producing tokens according to this invention are given by way of example only, and do not limit the scope of the invention.

EXAMPLE I

Seven sheets of 10 mil kraft paper impregnated with 35—45% by weight of phenol-formaldehyde resin, cured to approximately the 'B' stage, were assembled in a stack, and on one face thereof was placed a 3 mil sheet of *alpha*-cellulose paper impregnated throughout with 60—65% by weight of a melamine-formaldehyde resin to which had been added a radioactive isotope or element (carbon^{14} or uranium) in the form of a soluble compound. The carbon^{14} is added in the form of urea which can react with Melamine formaldehyde resin.

The entire assembly was pressed between flat metal plates at 1500 p.s.i. and a temperature of 150° C. to cure the resin and to consolidate the sheets into a unitary structure. The laminated product was then removed from the press and blanks having the diameter of a penny (about 1.25 inches) were cut from it.

Five tokens were constructed as described, with differing amounts of carbon^{14} or uranium, as shown in the Table, incorporated in the resin of the surface sheets on one side only.

The activity of these tokens measured on a conventional thin window geiger-counter having an effective aperture of 0.9 inch diameter, was as follows:—

Token	Isotope	Activity Active Side (Particles/Minute)	Activity Reverse Side (Particles/Minute)
1	C^{14}	3509	26
2	C^{14}	4018	19
3	C^{14}	4663	19
4	C^{14}	5807	21
5	U	4193	1553

The tokens were inserted in a vending machine whose sensing mechanism comprised an electric circuit including on one side of the token sensing position a geiger-muller tube adapted to influence the circuit positively when it received a number of emitted particles per minute within a predetermined range, and on the other side a geiger-muller tube adapted, in conjunction with the first tube, to influence the circuit positively only when it received less than 30 emitted particles per minute. Only Token 2 operated the delivery mechanism; Tokens 1, 3 and 4 were unacceptable because their levels of activity were above or below the setting for the first tube and Token 5 was unacceptable for although the first tube received a number of particles within the predetermined range and was thus activated, the second tube received more than 30 emitted particles per minute because of the high penetration energy of the isotope used, and so cancelled the positive action of the first.

Of course, the token must be inserted in the prescribed way, so that the melamine-formaldehyde resin layer faces the first tube, since otherwise it will not operate the mechanism at all.

EXAMPLE II

Five further tokens were produced by

the method described in Example I, with the exception that a three mil sheet of *alpha*-cellulose paper impregnated with 60—65% by weight of a melamine-formaldehyde resin to which had been added a radioactive isotope or element (carbon^{14} or uranium) in the form of a soluble compound was provided on both sides of the stack.

These tokens were inserted in a vending machine having the sensing mechanism described in Example I, with the exception that the second geiger-muller tube adapted in conjunction with the first tube to influence the circuit positively only when it receives less than 30 emitted particles per minute or equivalent energy was screened by aluminium foil .003 inch thick. The tokens operated the vending mechanism in a manner identical to that described in Example I but is was not necessary to insert the tokens any particular way round because the radioactive isotope was present on both faces and the aluminium foil reproduced the screening effect of the thickness of the single-sided tokens in Example I.

From the above Examples it is clear that the vending machine was able to distinguish both the energy and activity of the isotope or element used. The use of C^{14} is particularly advantageous since this isotope can only be obtained from a Government controlled source and is only available to registered users. The distinguishing of tokens made from this material from those made using the comparatively readily obtainable salts of uranium is thus of particular importance in ensuring that these tokens cannot easily be imitated.

The tokens according to this invention may, if desired, be provided with a removable protective covering or supplied in a protective container to eliminate any possible objections to their use on the grounds of health hazard.

Security documents in accordance with the invention and containing a weakly radioactive material are readily tested by placing them in position on a device of known type whereby such radioactivity can be detected, e.g. a sensitive surface connected to or forming part of a geiger-counter. Radiation of the low energy employed is very readily absorbed by even a thin layer of solid material; in particular the radiation emitted by C^{14} is appreciably absorbed by a layer of paper as thin as 0.0001 inch, so that when as is preferred the radioactive material is present on one surface only of the document it can be detected only when this surface is presented to the radiation detecting device. This enables the document to be instantly distinguished from one containing more easily available radioactive material such, for example, as those employed in luminous paint commonly used in marking the dials of watches and clocks, the radiation of which is much more penetrating. This has also the advantage that there will be no incentive to counterfeiters to incorporate such potentially more dangerous materials in their products.

It is, of course, immaterial which surface of the document is carrying the radioactive material, though it may in many cases be more convenient from the point of view of easy and unobserved testing to apply it to the back. As when it is incorporated in the paper, the radioactive material on the surface may be uniformly distributed over the whole of the printing, or it may be confined to selected parts thereof. Moreover, it may be applied separately from the visible printing to form an invisible or difficultly visible design. If in any particular case the extra complication is regarded as justified it may be applied in different designs to the two sides of the paper, especially by printing, but this will of course make it necessary to use more complex detecting devices, especially for rapid and on-the-spot testing.

The invention is not limited as to the nature of the device used to detect the radioactivity or identify the radioactive pattern or design when one is employed. Instruments, e.g. of the geiger-counter and radioautographic detection types, are already known in principle whereby this could be done. In the simplest case all that is required is that the device should comprise a surface which is sensitive to radioactivity and on which the document can be placed or over which it can be drawn. When the radioactive material is present as a design or pattern of any kind, from a simple strip or the like to more complex patterns, the surface may be provided with a mask of the same design or at least a sufficiently similar design to prevent the instrument responding to substantially different or differently placed radioactive designs. If desired, two sensitive surfaces may be provided between which the document can be placed to show by a single reading or operation that it is radioactive on one side only or that the radioactivity of the two sides differs in a particular way, but this will be less convenient in on-the-spot tests.

The manufacture of a security document according to the invention is illustrated in the following Example III:

Example III

A printing ink containing barium carbonate containing C^{14} was made by uniformly mixing a composition comprising blanc fixe, kaolin or silica (in amount about 2% of the total components of the ink) in a mechanical mixer with the other constituents listed below and then grinding the mixture until the required degree of dispersion and fineness

had been achieved. The ink produced had a radiation emission value of 5.0 millicuries per gram.

The composition of the ink, exclusive of the blanc fixe, kaolin or silica, was as follows:

Carbon black	16%	Cobalt Linoleate driers	1%
Bronze Blue	7%	Cobalt paste driers	4%
Wax Dispersion	10%	Barium Carbonate containing C^{14}	0.098%
Resin Varnish	62%		

The ink was used to print symbols on bank notes by means of a conventional numbering box on a dry offset process printing machine. The notes obtained when placed over the sensitive surface of a geiger-counter face downwards showed the presence of radioactivity, but when so placed face upwards showed substantially no radioactivity.

While the invention in regard to security documents has been described with particular reference to printing inks, the use of which is expected to be its major application, it includes other inks and also inked materials such as typewriter ribbons or carbon papers, the transferable material of which similarly contains weakly radioactive material.

A vending machine suitable for use with tokens of the type described in this specification has been described in the specification of our co-pending Application No. 11441/63 (Serial No. 990255).

WHAT WE CLAIM IS:—

1. Security documents and monetary tokens, which comprise one or more radioactive marks formed from a radioactive material of atomic number less than 15 and wherein the radiation emitted is *beta* radiation energy of less than 0.5 MeV.

2. A security document according to claim 1, wherein the radiation has an energy of less than 0.2 MeV.

3. A security document according to claim 2, wherein the radioactive material is provided over the whole area of the document.

4. A security document according to claim 2, wherein the radioactive material is provided in a predetermined pattern on the document.

5. A security document according to any one of claims 2 to 4, wherein the radioactive material is incorporated in the material of the document.

6. A security document according to any one of claims 2 to 4, wherein the radioactive material is applied to the surface of the document.

7. A security document according to claim 6, wherein the radioactive material is applied to one surface only of the document.

8. A security document according to claim 6, wherein the radioactive material is applied in different patterns on the opposite sides of the document.

9. A security document according to claim 6, 7 or 8, wherein the radioactive material is included in at least some of the ink used to print the document.

10. A security document according to claim 9, wherein the ink contains barium carbonate containing C^{14}.

11. A method of making a security document in accordance with claim 1 wherein the radioactive material is incorporated in the paper pulp from which the document is manufactured.

12. A method of making a security document in accordance with claim 1 wherein a radioactive material is applied to the surface of the document.

13. A method according to claim 12, wherein the radioactive material is included in a resinous coating applied to one or both surfaces of the document.

14. A method according to claim 12, wherein the radioactive material is applied to the surface of the document by being included in a printing ink used in the production of the document.

15. A method according to claim 12, 13 or 14, wherein the radioactive material is applied in a predetermined pattern to a surface of the document.

16. A token according to claim 1, which comprises a radioactive material of atomic number less than 15 and omitting a radiation of energy less than 0.2 MeV.

17. A token according to claim 16, wherein the radioactive material is present in, on, or beneath one face only of the token.

18. A token according to claim 16, wherein the radioactive material is present in, on, or beneath both faces of the token.

19. A token according to claim 16, which comprises one or more synthetic resins in moulded, reinforced or laminated form.

20. A token according to claim 19, wherein the radioactive material is mixed with a resin comprising the token.

21. A token according to claim 19 where the radioactive material is a compound which can react with the resin comprising the token.

22. A token according to claim 19, wherein the radioactive material is contained in a reinforcing or carrier material for a resin comprising the token.

23. A token according to any one of claims 16 to 19, wherein the radioactive material is present in the form of ink or other

marking or colouring ingredient applied externally or internally to the token.

24. A token according to any one of claims 16 to 23, wherein a barrier material is included in the token, such barrier material being resistant to radiation for reducing the energy of radiation emitted by the token.

25. Security documents and monetary tokens substantially as herein described.

26. Methods of making security documents and tokens substantially as herein described.

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